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Marshall Space Flight Center



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Isolated Output for Class-D DC Amplifiers

The problem:

High-efficiency switching mode (class-D) power amplifiers are limited in output amplitude to the power supply voltage and also are referenced to supply ground. It is often desirable to isolate the amplifier output so that load ground may be independent of supply ground.

The solution:

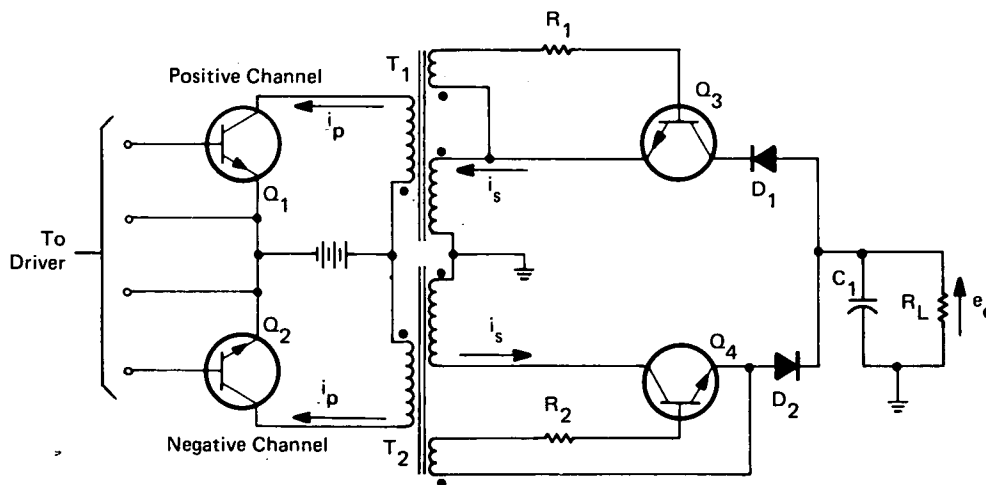
A transformer-coupled output stage has been developed for use with pulse-width modulated class-D dc amplifiers.

How it's done:

The transformer-coupled output circuit is comprised of two channels corresponding to negative and positive input signals. The schematic shows only the output stage of the complete amplifier which requires positive base drive for both (Q_1 and Q_2) drive transistors.

Since the two channels are similar, only the negative channel will be discussed in detail. Assume that the channel associated with Q_2 is operating, that the pulse-

width-modulated driving signal (a train of constant-amplitude, positive pulses) has remained unchanged for several cycles, and that the time constant of the filter capacitor C_1 and load R_L is large enough that the output voltage, e_o , approximates some positive dc level. At time "zero", a pulse drives Q_2 into saturation. Since the voltage drop across Q_2 is quite small, almost the entire supply voltage is applied across the associated primary windings of transformer T_2 . The polarity of the voltage across diode D_2 and the phasing of the transformer secondary is such that current will not flow in the secondary while Q_2 remains saturated and current is flowing in the primary. During this time, Q_4 , one of the clamping transistors, is reverse-biased by the voltage from the base-drive winding. Assuming that the current in all of the transformer windings is initially zero, the primary current waveform describes a ramp. As current flows in the primary winding, energy is stored in the core of the transformer, because current flow may not occur at this time in either the secondary or Q_4 base-driven windings.



Transformer-Coupled Output Circuit Schematic

(continued overleaf)

At time π , Q_2 is driven to cut-off by the driver. As current flow ceases in Q_2 , the voltage across the primary reverses polarity in response to the change in current. At the same moment, the secondary and the Q_4 base-drive winding voltage polarities also reverse, driving Q_4 on and forward-biasing D_2 . As the magnetic field begins to collapse, current flows in the secondary, removing the stored energy from the core of T_2 . The secondary current waveform is a ramp of negative slope.

During this sequence of events, the role of Q_3 , the other clamping transistor, is to prevent the positive output voltage from being short-circuited by D_1 and the secondary of T_1 . If an output voltage of only one polarity is desired, then just one channel of the output circuit is required.

The amplitude of the secondary-current triangular pulse is a function of the duration of the driving pulse. Therefore, this output circuit converts the pulse-width modulated driving signal to a pulse-amplitude modulated signal. The output capacitor C_1 serves as a filter to remove carrier frequency components. A more elaborate low-pass filter may be connected between C_1 and the load R_L for improved carrier filtering.

Note:

Requests for further information may be directed to:
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Patent status:

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